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Specification and Drawing, as originally filed, with Application for Patent Serial No: **2,315,544**, on August 8, 2000, by **CALFRAC WELL SERVICES LTD. and CHEMERGY LTD.**, assignee of Travis L. Allan, Junad Amin, Alan K. Olson and Ronald G. Pierce, for "Fracturing Method Using Aqueous or Acid Based Fluids".

S. Gregoria

Agent certificateur/Certifying Officer

May 23, 2003

Date

Canada

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ABSTRACT

An improved method and fracturing fluid for hydraulic fracturing of a subterranean formation, the fracturing fluid comprising a surfactant, a water soluble or dispersible anionic organic salt, an acid and a low molecular weight organic solvent.

FRACTURING METHOD USING AQUEOUS OR ACID BASED FLUIDS

Field of the Invention

The present invention relates to the field of fracturing fluids, in particular, surfactant based fracturing fluids.

Background of the Invention

A fracturing fluid is a fluid that is pumped into a hydrocarbon-bearing geological formation under high pressure to open fractures in the formation, thereby to facilitate the flow of hydrocarbons from the formation. Fracturing fluids are preferably viscous, so as to be able to carry proppants such as sand that wedge into the fractures that are forced open in the formation.

Conventional fracturing fluids contain high molecular weight polysaccharides based polymers, as gelling agents. These polymers are associated with build-up of filter cake on the fracture face. If the filter cake is not completely removed, it will impede flow of reservoir fluid and hence reducing the effectiveness of the fracture. Control and limiting of residual filter cake becomes extremely important when dealing with problematic formations. Alternative to the conventional polymeric system is the novel development of the present invention.

The present invention is a non-polymeric visco-elastic system. The system is based on surfactant chemistry. Although surfactant based systems have been employed in gravel packing operations since the early 1980s (SPE 17168), further development and refinement of surfactant chemistry has yielded surfactant based fracturing fluids. Some of these techniques are discussed and revealed in Canadian Patent No. 1,298,697 and U.S. Patent No. 5,964,295.

The advantage of a surfactant based fracturing fluid over a polymeric gel based fluid is that micelle formation in surfactant fluids is virtually instantaneous, but does not alter the actual chemical composition of the fluid. That is, once a critical concentration of surfactant molecules is reached, they will aggregate as micells,

thereby increasing the viscosity of the fluid, but without changing the chemical concentration. Therefore, no chemical initiator is required, and viscosity increase occurs uniformly throughout the fluid.

The key to the present invention therefore is the novel use of amphoteric glycinate surfactant, as an additive. In acidic conditions, the glycinate exhibits cationic properties. When the glycinate is combined in proper ratio with anionic salt such as Sodium Xylene Sulfonate in a neutral to acidic environment of an aqueous stimulation fluid (water or acid) it is believed to form highly structured three dimensional micelles. The interference/interaction of the micelles imparts the desired viscoelastic properties to base stimulation fluid. The required cationic activity of the glycinate is ensured by utilization of an organic acid in the formulation of the additive. The purpose of a low molecular alcohol used in the system is to serve as a dispersability agent for making the system field friendly.

The viscoelastic properties imparted to stimulation fluid are controlled by two mechanisms:

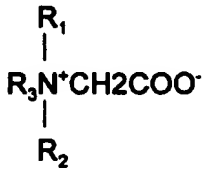
1. By varying total additive added to the stimulation fluid (0.1-5.0%); and
2. By controlling the ratio between the salt and the glycinate (0.15-0.6% of glycinate).

Another novel use of amphoteric surfactant is the utilization of change in its ionic properties with pH to control the break mechanism of the gel. As the pH of the system is increased above 6.5 the ionic properties of the glycinate change from cationic to anionic. This change de-stabilizes the micellar structure, hence, resulting in the break of the gel, allowing for easy post frac cleanup. In the earlier technologies, to attain a break the system had to encounter formation fluids (oil) in order to de-stabilize the gel structure. Simple adjustment in pH did not break the gel in the earlier inventions. This limited the use of the system to those wells that contained oil or those that produced condensate. In the present invention the pH of the system can be increased easily by utilization of alkaline compounds such as carbonates, oxides, amines and etc.

As the temperature of the system increases the interaction between the ion weakens, resulting in decrease in stability of the micells. The upper limit of the gel appears to be around 65°C. The upper temperature range may be further increased by utilization with alternative salts or using a surfactant with different length of the alkyl group.

In a broad aspect, then, the present invention relates to a fracturing fluid comprising:

(i) a surfactant having the general formula



where R_1-R_2 are each an aliphatic group of C1-C4, branched or straight chained, saturated or unsaturated, R3 is a group of C12-C22, branched, straight chained or cyclic, saturated or unsaturated;

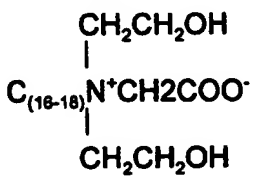
(ii) a water soluble or dispersible anionic organic salt;

(iii) an acid; and

(iv) a low molecular weight organic solvent.

The attached drawing is a graph of viscosity % against pH.

It will be observed, then, that the present invention is a four component system. The primary component, the surfactant, is preferably a dihydroxyethyl tallow glycinate having the structure:



The second component, the salt is preferably sodium xylene sulfonate. However, other similar salts may be used, such as potassium, zinc, ammonium,

magnesium (etc.) Xylene or toluene sulfonate. In addition, other naphthalen backboned sulfonate salts may be used.

As to the acid component, any organic or mineral acid may be used to lower the pH below 6.5. Acids that have been found to be useful include formic acid, citric acid, hydrochloric acid, and so on. The preferred acid is acetic acid because it is universally available, low cost, and safe to handle.

The final component, the alcohol solvent is used to modify the viscosity of the solvent, usually water, by altering its polarity, which will result in reduced viscosity of the miscellar formations.

In an aqueous fluid, the surfactant composition of the present invention is added in a concentration of from about 0.1% wt to about 5.0% wt. The actual composition in a preferred composition will be, for example:

Glycinate	0.65
Organic salt	0.20
Acid	0.025
Solvent	0.125

Some variations, up to about 20% per component, are possible.

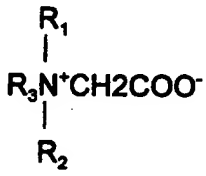
The formulation of the present invention is also compatible with CO_2 and N_2 foams, over a temperature range of 5°C - 80°C. Unfoamed, the upper temperature limit of the present invention is about 65°C.

In order to lower the viscosity of the surfactant based fracturing fluid of the present invention, the pH of the fluid is raised by the addition of an alkaline substance such as magnesium oxide or sodium hydroxide. This effectively raises the critical micelle concentration of the fluid, resulting in disassociation of the micelles that have been formed. Accordingly, it will be understood that formation clean-up is quickly accomplished, without caking or clogging.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A fluid for fracturing a subterranean formation comprising:

   (i) a surfactant having the general formula

   where R_1-R_2 are each an aliphatic group of C1-C4, branched or straight chained, saturated or unsaturated, R3 is a group of C12-C22, branched, straight chained or cyclic, saturated or unsaturated;

   (ii) a water soluble or dispersible anionic organic salt;

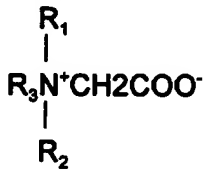
   (iii) an acid; and

   (iv) a low molecular weight organic solvent.

2. A method of fracturing a subterranean formation comprising the steps of:

   providing a visco-elastic surfactant based hydraulic fracturing fluid comprising:

   (i) a surfactant having the general formula

   where R_1-R_2 are each an aliphatic group of C1-C4, branched or straight chained, saturated or unsaturated, R3 is a group of C12-C22, branched, straight chained or cyclic, saturated or unsaturated;

   (ii) a water soluble or dispersible anionic organic salt;

   (iii) an acid; and

   (iv) a low molecular weight organic solvent, and;

   pumping said fracturing fluid through a well bore and into a subterranean formation at a sufficient pressure to cause fracturing of said formation.

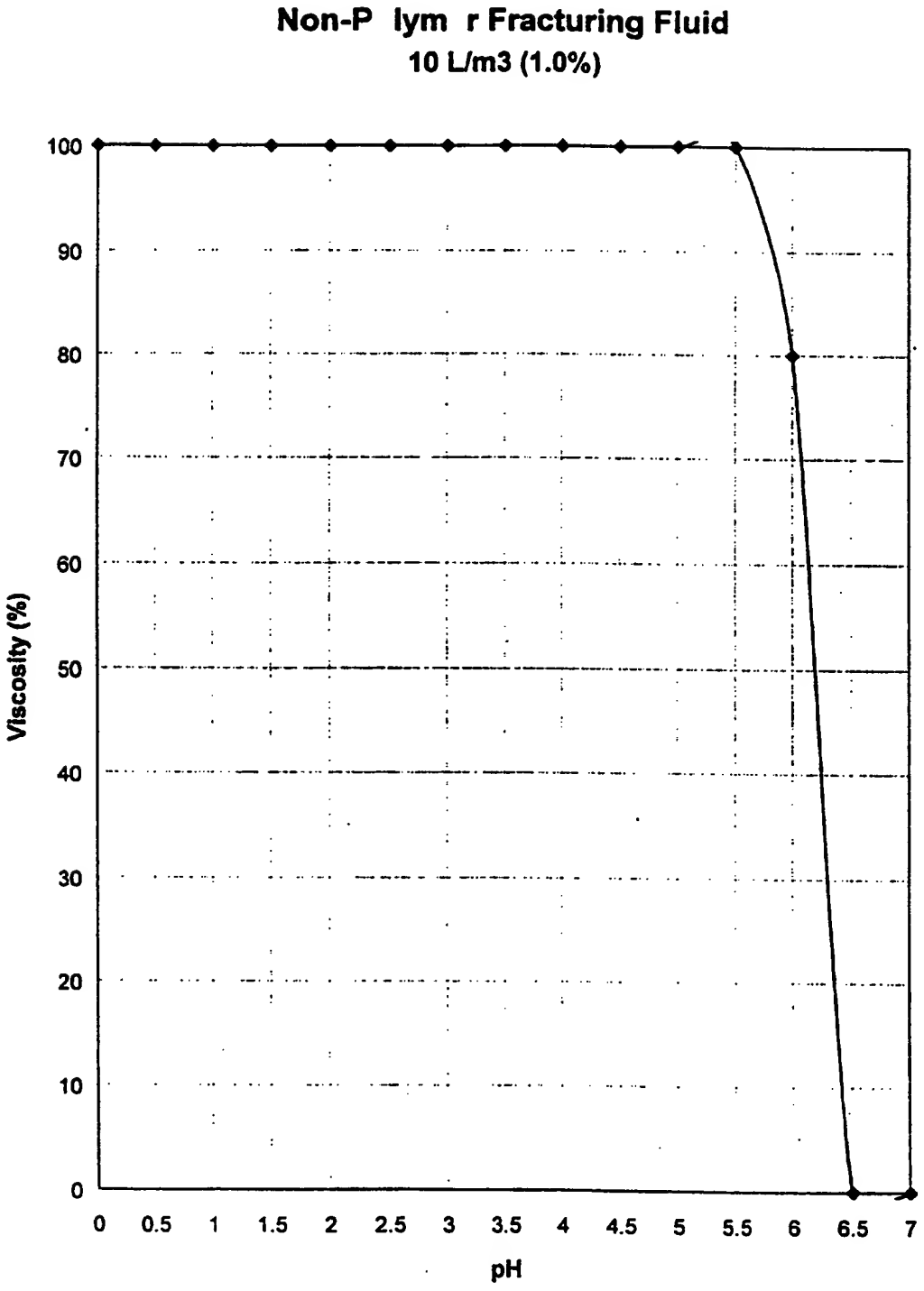

Non-P lym r Fracturing Fluid
10 L/m3 (1.0%)
Viscosity (%)
100
90
80
70
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
pH

FIGURE 1